CANspy

32/16-channel CAN Port Switch

user manual & reference
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Version History		
Version	Date	Comments
1.3	13 Mar 2009	Some updates to text and chapter naming; addition of a figure with a depiction of a CANspy on a bus and a figure with pictures of the ATLAS MDT system.
1.2	2 Dec 2008	New pictures.
1.1	25 Nov 2008	Corrections in text and pictures.
1.0	10 Nov 2008	Describes firmware version "CS10.0000".

Table 1. Document change record.

1 Description

CANspy is a 1HE high 19-inch module, allowing a user to connect a CAN interface port to an existing CAN bus, selectable from up to 32 CAN buses. These CAN buses are connected in pairs to the sixteen D9 connectors on the frontpanel of the *CANspy* module. If CAN cables with standard connector layout are used, up to 16 CAN buses can be connected to the *CANspy* module.

The selected CAN bus connection is routed to the 'spy' connector on the backpanel of the *CANspy* module, which in turn is typically connected to a CAN interface port on a PC, thus allowing a user to connect his PC to anyone of the up to 32 CAN buses connected to the *CANspy*, for 'spying' on or active control of this bus. The selection of a bus is controlled through a separate CAN bus connection on the *CANspy* running at a bit rate of 125 kbit/s. On this CAN connection the higher-level ***CANopen*** protocol [1] [2] is used as the communication protocol standard. The CAN messages used for the *CANspy* operation are described later in this document in the section on the *CANspy* firmware.

So by using only two CAN ports on his PC a user is able to connect to an almost unlimited number of CAN buses, since *CANspy* modules can be daisy-chained, on its controlling CAN bus as well as its 'spy' port. In the latter case a user should take care to connect only one CAN bus of all *CANspy* modules on the chain, in order not to make a connection between two independent CAN buses!
A software tool is provided for controlling multiple *CANspy* modules in such a setup. A brief description of the tool can be found in section 3.

Note that connecting to a CAN-bus using the *CANspy* module implies that a 'stub' is created on the bus (i.e. a cable branch) as illustrated in Figure 1, which may affect the reliability of the bus if it is long. This needs to be taken into account. The stub should be kept as short as possible. In the example application described below (where all CAN-buses run at 125 kbit/s) no adverse effects were found using three *CANspy* modules 'in series' and a stub with a length of a few meters. Nevertheless it is recommended not to leave a *CANspy* connection connected unnecessarily in a running system.

A *CANspy* module is equipped with a small display (LCD, with 2x8 characters) on its frontpanel, showing the current state of the switch, i.e. *standby* (which means not connected) or *connected*. The user can store an 8-character string per CAN-bus channel which is displayed on the LCD whenever the channel is selected.

The heart of the *CANspy* module is an ATMEL AT90CAN64 microcontroller with integrated CAN controller for the control and monitoring of the *CANspy* module. The switching part consists of two 16-channel TLC5923 LED driver devices, which are used to drive the solid-state relays to connect the CAN-port signals (**CAN-H**, **CAN-L** and **Ground**) from an 'in'-port (on the front side of the module) to the 'spy'-port (on the back side of the module).

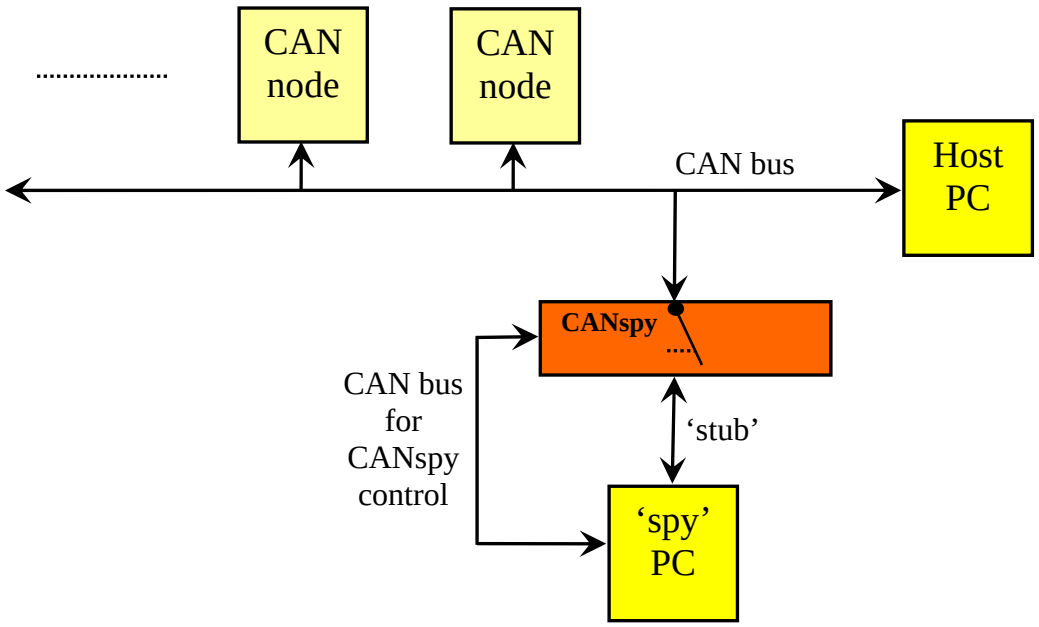


Figure 1.Schematic drawing of a CANspy module connected to a CAN bus.

See the pictures in **Figure 2** for an example of the application of *CANspy* modules. The pictures illustrate a real-life example of *CANspy* modules used in the ATLAS experiment's MDT muon chamber system, consisting of ca. 1150 chambers. This system is equipped with more than 80 CAN-buses connecting to devices used to monitor various sensors on each muon chamber and to configure and monitor the frontend electronics of each muon chamber. All CAN buses end up on interfaces in PCs (up to 12 CAN-buses per PC). Power for the devices connected to the buses is fed through wires running through the same cables as the CAN buses. The power is provided by the power supplies. These power supplies relay the CAN bus signals and conveniently provide an additional CAN-bus connector on their frontpanel for the CAN bus cable they supply with power, and this is where the *CANspy* modules are connected to. Three *CANspy* modules are used to connect all CAN buses. This allows a user (system expert) to remotely connect to any of the buses from only one of the PCs, either to monitor the running system or to look at or debug for example a problem on a device on a particular CAN bus

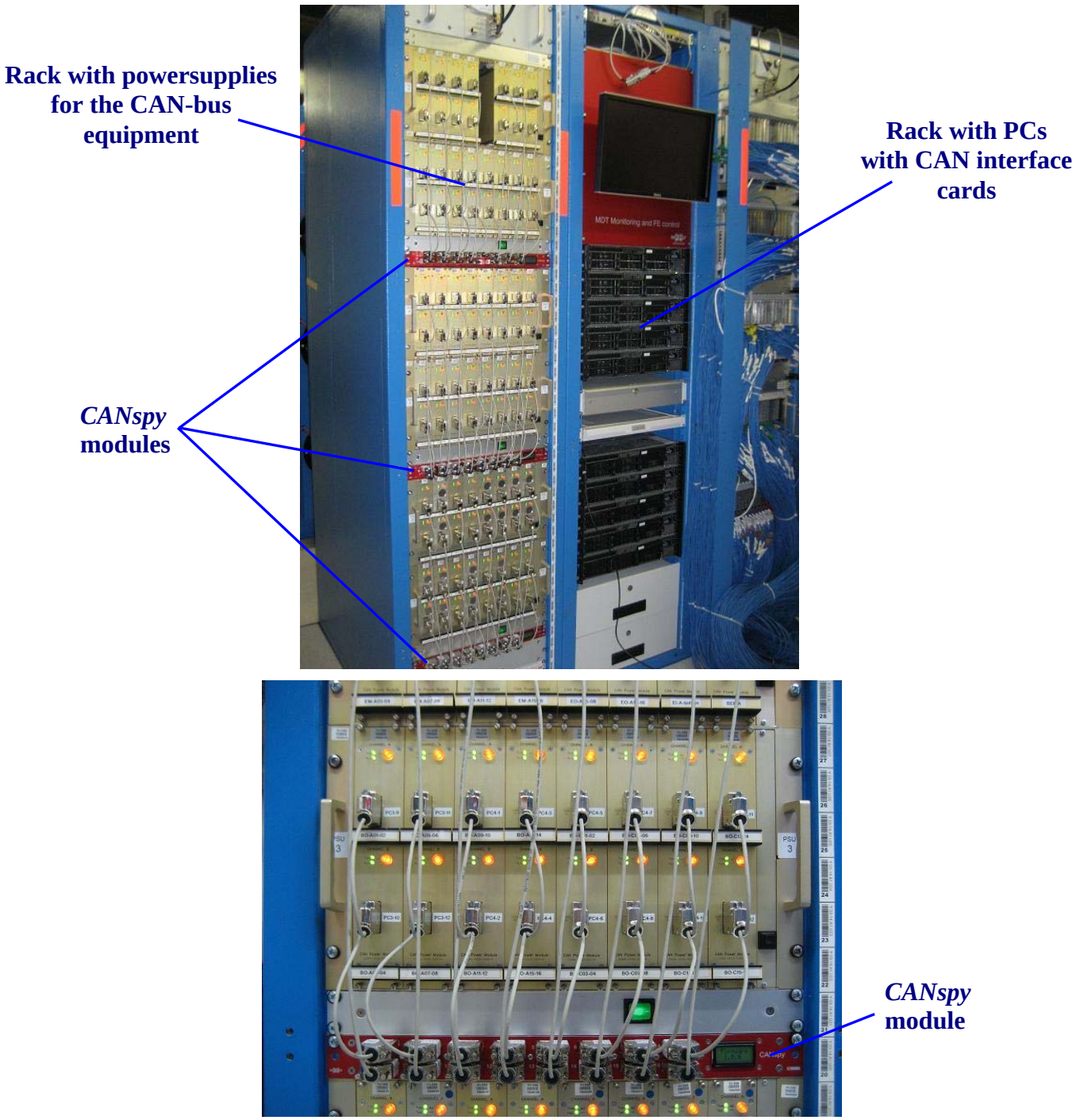


Figure 2.Picture at top: the rack on the left contains the power supplies for the CAN-bus equipment. Three *CANspy* modules connect to each bus through the CAN-connector available on the frontpanel of a power supply. The rack on the left holds the PCs that contain the CAN interfaces that connect to each of the around 80 CAN-buses. Each PC connects to up to 12 CAN-buses.

Picture at bottom: detail of the CAN-bus power supply rack with *CANspy* module. Each *CANspy* module connector connects to 2 CAN-buses using a 1-to-2 fanout cable with D9 connectors.

2 Connectors and Interfaces

Figure 3 shows pictures of the *CANspy* module front and back panels, highlighting its connectors. The layout of the connectors is detailed in **Table 2** and **Table 3**.

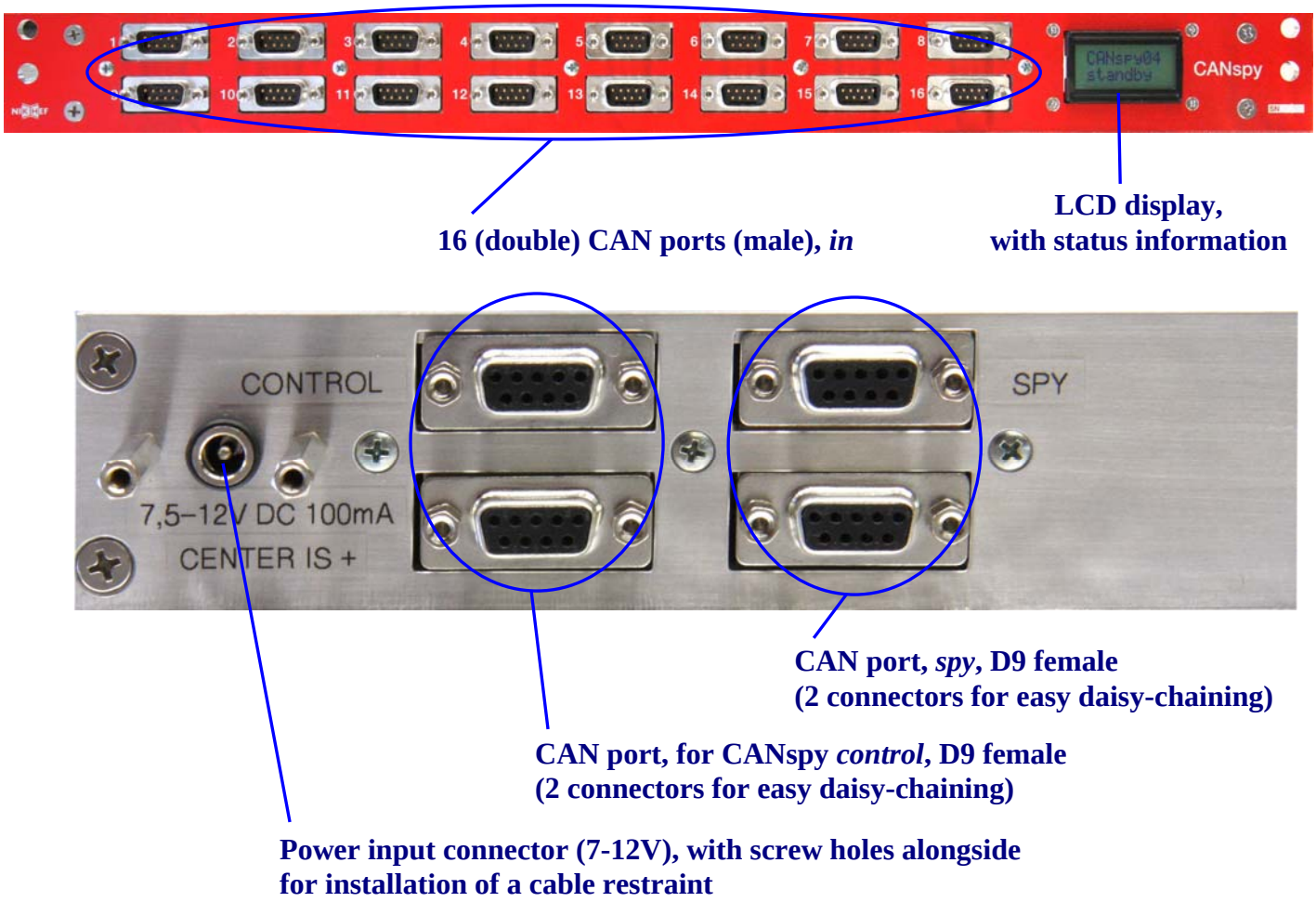
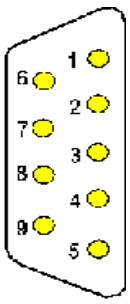
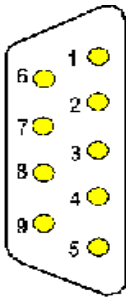

CANspy
CONTROL
SPY
7,5–12 V DC 100mA
CENTER IS +
16 (double) CAN ports (male), *in*
LCD display,
with status information
CAN port, *spy*, D9 female
(2 connectors for easy daisy-chaining)
CAN port, for CANspy *control*, D9 female
(2 connectors for easy daisy-chaining)
Power input connector (7-12V), with screw holes alongside
for installation of a cable restraint

Figure 3.Views of the *CANspy* module frontside and backside.



function	pin	pin	function
		1	**CAN-L, bus 'B'**
CAN-H, bus 'B'	**6**	**2**	**CAN-L, bus 'A'**
CAN-H, bus 'A'	**7**	**3**	**CAN-GND, bus 'A'**
not connected	**8**	**4**	**CAN-GND, bus 'B'**
not connected	**9**	**5**	**CAN-SHIELD**

Table 2. Layout of the *CAN* connectors ('in') on the frontside of the *CANspy* module. Bus 'A' is connected according to the CAN(open) standard, so if standard cables are used up to 16 CAN-buses can be connected to the CANspy module and only the 'A' buses can be switched then.



function	pin	pin	function
		1	*not connected*
not connected	**6**	**2**	**CAN-L**
CAN-H	**7**	**3**	**CAN-GND**
not connected	**8**	**4**	*not connected*
not connected	**9**	**5**	**CAN-SHIELD**

Table 3. Layout of the *CAN* connectors ('CONTROL' and 'SPY') on the backside of the *CANspy* module; there are 2 connectors for easy daisy-chaining multiple modules on one CAN-bus. All 9 pins of the connectors of each pair are 1-to-1 connected.

Note that the CAN bus for control of the *CANspy* module(s) should be terminated at the last *CANspy* module on the bus.

The module's CAN node identifier is stored in EEPROM and can be changed remotely (see Object Dictionary index 3300h and 3301h in section 4.5) and is shown periodically on the *CANspy* display (when the module is in 'standby', i.e. no CAN bus 'in' is connected to 'SPY').

The *CANspy* module's serial number, which it has been given during production testing, can be read out remotely (see Object Dictionary index 3100h in section 4.5) and is also shown periodically on the *CANspy* display (when the module is in 'standby').

3 *CANspy Control* Software

The ***CANspy Control*** program provides a user interface for controlling multiple *CANspy* modules (all connected to the same controlling CAN bus), whereby only a single CAN port connection is 'active' at any time. See **Figure 4**. If a new connection is selected on a another *CANspy* module a 'disconnect' command is sent to all other *CANspy* modules first. In this way it is possible to daisy-chain the 'spy' ports of the *CANspy* modules, without accidentally connecting two independent CAN buses to each other.

The program also provides an interface for setting and modifying the labels (names) for the inputs. See **Figure 5**. The labels are stored in the *CANspy* module. Labels are 8-character strings that allow the user to assign more user-friendly names for the CAN inputs rather than to have to remember which input number represents which CAN bus.

The software runs under MS Windows and supports all *Kvaser* CAN-bus interfaces (a version for *National Instruments* CAN-bus interfaces can be made available on request).

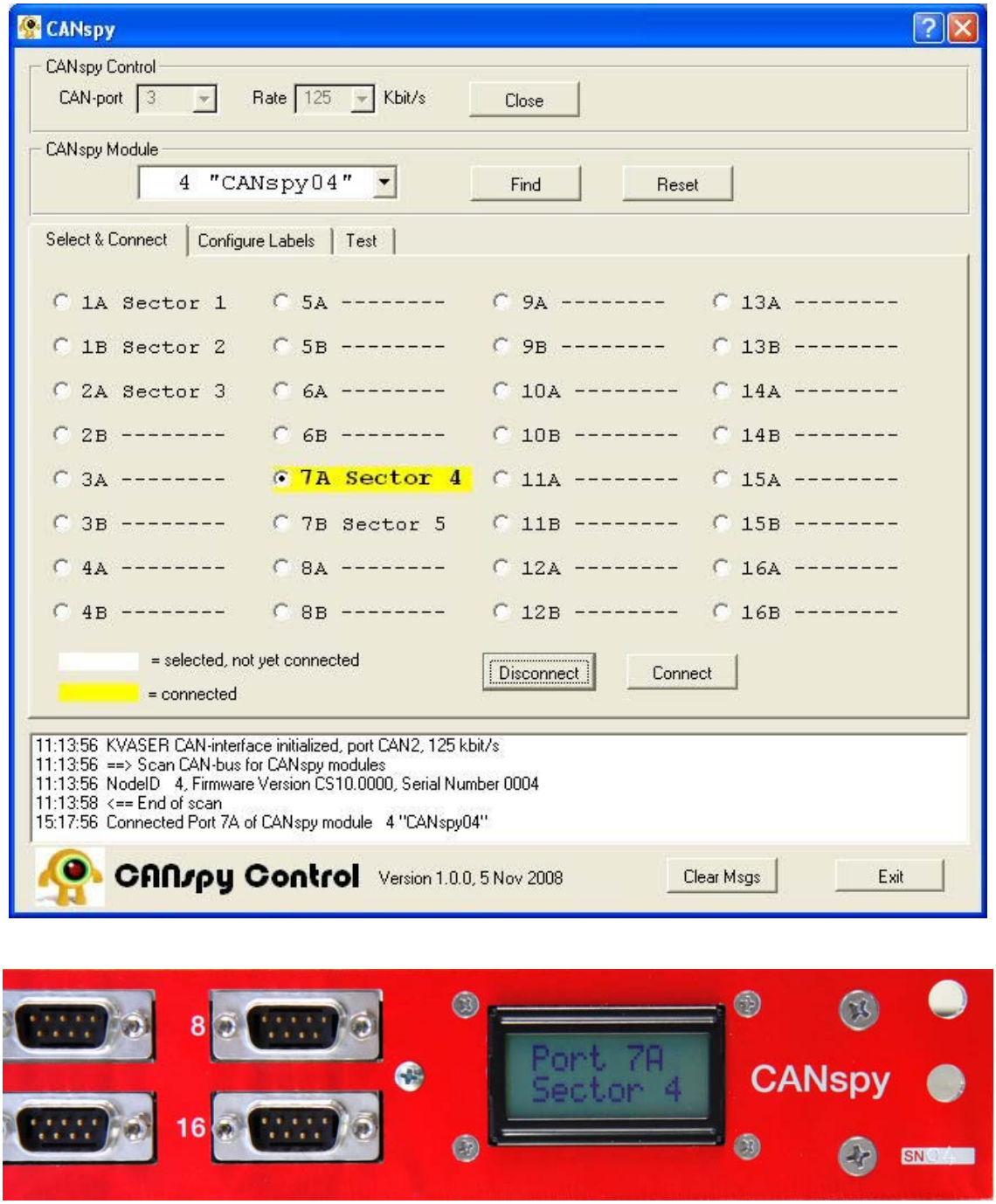


Figure 4. User interface for the CAN-bus input selection (top) and the *CANspy* display reflecting the status as shown in the user interface (bottom). In this case input 7A with label “Sector 4” is selected and connected. In subwindow *CANspy Control* the CAN-bus interface port through which the CANspy modules are controlled, can be selected. This automatically triggers a scan for *CANspy* modules present on the bus. In subwindow *CANspy Module* one of the CANspy modules found on the bus can be selected from the drop down menu. In this case a *CANspy* module with *CANopen* address 4 and label “CANspy04” is selected. By selecting any one of the inputs 1A to 16B and then clicking the *Connect* button this input is connected to the *CANspy* ‘spy’ connector.

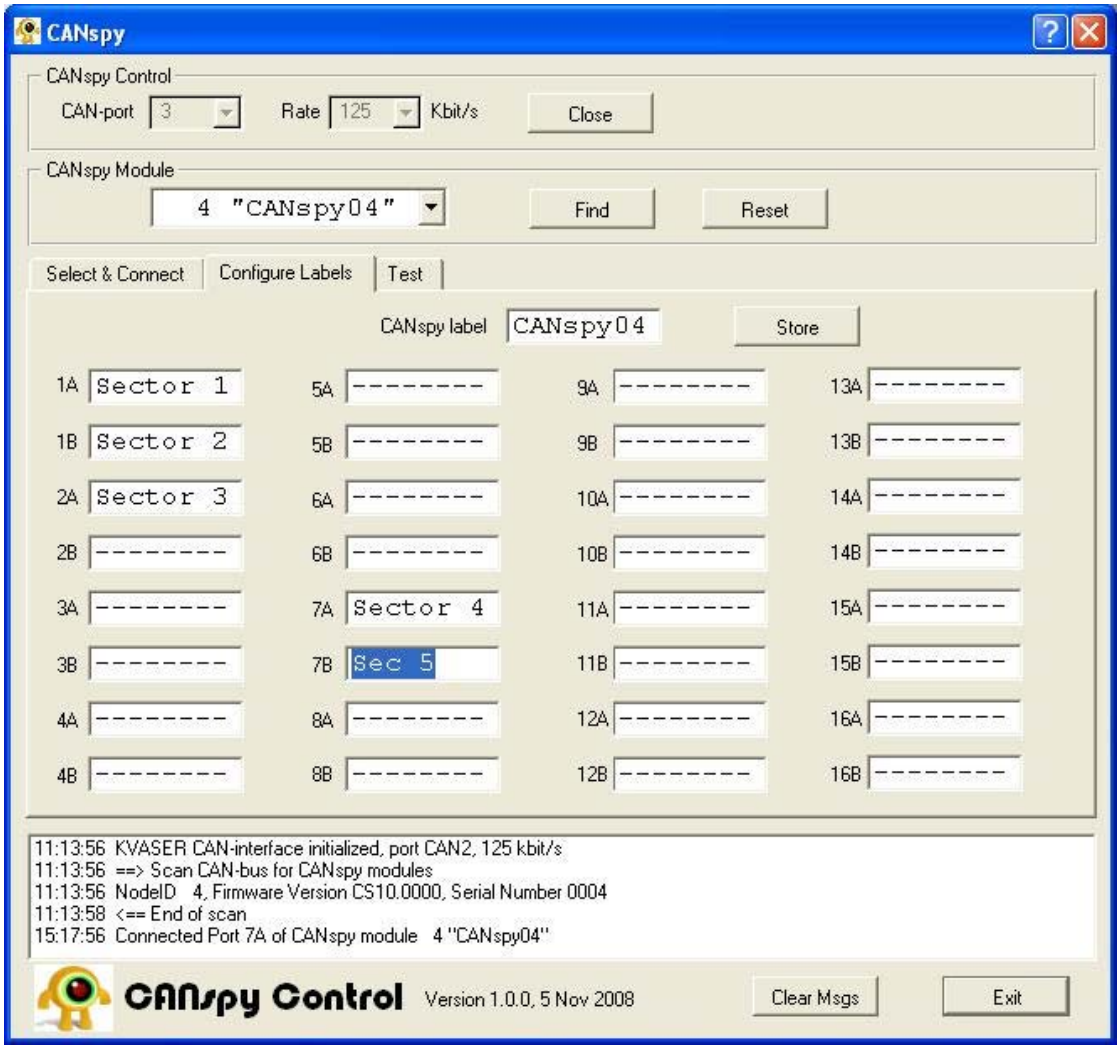


Figure 5. User interface for module and port label editing and storage. Labels are 8 characters long at maximum. By clicking the *Store* button labels are stored permanently in the *CANspy* module. A label shown as dashes only ("--------") has not been given a name yet. There is one label for each CAN input port and one label for the *CANspy* module itself which is conveniently shown in the drop down menu for the *CANspy* module selection.

4 *CANspy* CANopen Firmware

4.1 Initialisation

When the *CANspy* firmware initialises, the hardware devices are reset and configured (LCD and a switch chip) and error counters and registers are reset.

After power-up, watchdog reset, manual reset or a *CANopen* initiated reset action (i.e. by an NMT *Reset-Node* message, see below) a CANopen node sends a so-called ***Boot-up*** message (as defined by the *CANopen* standard) as soon as it has finished initializing (hardware, software); this is a CAN-message with the following syntax:

CANspy module (NMT-Slave) → Host (NMT-Master)

COB-ID	Data Byte 0
700h + *NodeID*	0

NodeID is the CAN node identifier stored in the *CANspy*'s EEPROM. *NodeID* is in the range between 1 and 127.

To generate a *soft* reset the following *CANopen* NMT message must be sent:

Host (NMT-Master) → CANspy module (NMT-Slave)

COB-ID	Data Byte 0	Data Byte 1
000h	81h (*Reset_Node*)	*NodeID* or 0 (0: all nodes on the bus)

There is no reply to this message.

Note that at power-up it is the *Bootloader* application firmware that becomes active first and is in control of the *CANspy* module; the Bootloader reports its presence by sending the following Emergency message (see also section 4.4):

Bootloader → Host

COB-ID	Byte 0-1	Byte 2	Byte 3-7
080h + *NodeID*	Emergency Error Code (00h 50h)	Error Register (Object 1001h) (80h)	Manufacturer specific error field (FEh 00h 64h ZZh 00h) (ZZh = MCUSR)

(*MCUSR* = MCU Status Register; for details see section 4.6 or the AT90CAN64 microcontroller datasheet).

Having the Bootloader activate at power-up guarantees that it is always possible to upload new application software to the module, even when the application currently programmed is faulty or corrupted.

After about 4 seconds the Bootloader automatically jumps to the application. Alternatively, the Bootloader starts the application immediately, if it receives an NMT *Reset-Node* message –as shown above- within this period.

4.2 Node Guarding and Life Guarding

Node Guarding in CANopen is a mechanism whereby an *NMT-master* checks the state of other nodes on the bus, at regular intervals. It can do this in one of two different ways:

1. The master sends a Remote Transmission Request (RTR) for the Node Guard message, to each node on the bus, in turn; a node that receives the RTR, sends the Node Guard message, which contains one data byte indicating the (CANopen) state of the node, as well as a toggle bit. If a node does not reply the master should signal this to the higher-level software and/or take appropriate action.
   The RTR for the Node Guard message looks like this (a Remote Frame, so the CAN-message has no data bytes):

   Host (NMT-Master) → CANspy module (NMT-Slave)

COB-ID
700h + *NodeID*

   The reply Node Guard message from a node looks like this:

   CANspy module (NMT-Slave) → Host (NMT-Master)

COB-ID	DataByte 0
700h + *NodeID*	bit 7: *toggle bit*, bit 6-0: *state*

2. Each node on the bus sends a Heartbeat message at regular intervals; typically, the NMT-master monitors these messages and keeps a time-out period for each node. The master detects nodes that stop sending their Heartbeat messages and should signal this to the higher-level software and/or take appropriate action.
   A Heartbeat message looks like this:

   CANspy module (Heartbeat producer) → Consumer(s) (e.g. NMT-Master)

COB-ID	DataByte 0
700h + *NodeID*	*State*

State is one of these CANopen states: 0 (*Initializing*), 4 (*Stopped*), 5 (*Operational*) or 127 (*Pre-operational*). Note that this makes the *Boot-up* message the first Heartbeat message after a node reset (see previous section).

According to the CANopen standard, a node is not allowed to support both Node Guarding and Heartbeat protocols at the same time. The *CANspy* module supports both methods of Node Guarding (but indeed not at the same time), i.e. it can send the Node Guard message or it can send the Heartbeat message with an interval, which is configurable in *OD* index 1017h.

Life Guarding in CANopen is a mechanism whereby a node checks the aliveness of the host or master, by applying a time-out on messages received. CANopen defines that the message to time-out is the RTR for the Node Guard message, sent by the NMT-master; however, the *CANspy* module resets its Life Guarding timer at each properly received message addressed to it.

Life Guarding is controlled through *OD* objects 100Ch and 100Dh. In the *CANspy* module the Life Guarding time-out can be set between 1 and 255 seconds, by setting *OD* index 100Dh to the corresponding value, or can be switched off, by setting *OD* index 100Dh to zero.

If a Life Guarding time-out occurs, the node should take whatever appropriate action. The *CANspy* module resets and reinitializes the CAN-controller, and (tries to) resume(s) normal operation, after sending an Emergency message (see section 4.6).

4.3 Configuration Storage

4.3.1 Storing Parameters and Settings

Parameters and settings can be stored permanently onboard in non-volatile memory (EEPROM) by writing string "save" to *OD* index 1010h. The ***SDO*** mechanism is used to accomplish this, using the following message:

Host → CANspy module

COB-ID	**Data Byte**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
600h + *NodeID*	0x23	0x10	0x10	*subindex*	73h ('s')	61h ('a')	76h ('v')	65h ('e')

with *OD* index 1010h in byte 1+2 and *subindex* in byte 3 with *subindex*:
= 1: store all parameters (as listed for *subindex* 2 and 3).
= 2: store communication parameters (concerning CAN, PDOs and Node- and Life Guarding).
= 3: store application parameters (not applicable for *CANspy*).
= 4: see next section.

If the store-operation succeeded the *CANspy* module sends the following reply:

CANspy module → Host

COB-ID	**Data Byte**						
	0	**1**	**2**	**3**	**4**	**5**	**6-7**
580h + *NodeID*	0x60	0x10	0x10	*subindex*	–	–	–

If the store-operation did <u>*not*</u> succeed the *CANspy* module sends the following reply (***SDO** Abort Domain Transfer*, error reason: 'hardware fault' (for more details see [1])):

CANspy module → Host

COB-ID	**Data Byte**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
580h + *NodeID*	80h	10h	10h	*Subindex*	0	0	6 (Error Code)	6 (Error Class)

Parameters can be reset to their default values (by invalidating the corresponding contents of the EEPROM) by writing to *OD* index 1011h, using this time the string "load" (6Ch, 6Fh, 61h, 64h) in bytes 4 to 7 of the ***SDO***. Note that the default values take effect only after a subsequent reset of the module. The default parameter values are listed in the *OD* tables in section 4.5.

The Object Dictionary tables in section 4.5 show which settings can be stored in EEPROM: these are marked by an asterisk (*) in the first column
(Note that storage of the *CANspy* Serial Number is handled separately).

4.3.2 EEPROM Memory Map

Table 4 below details the layout of the AT90CAN64 microcontroller EEPROM usage by the *CANspy* application firmware.

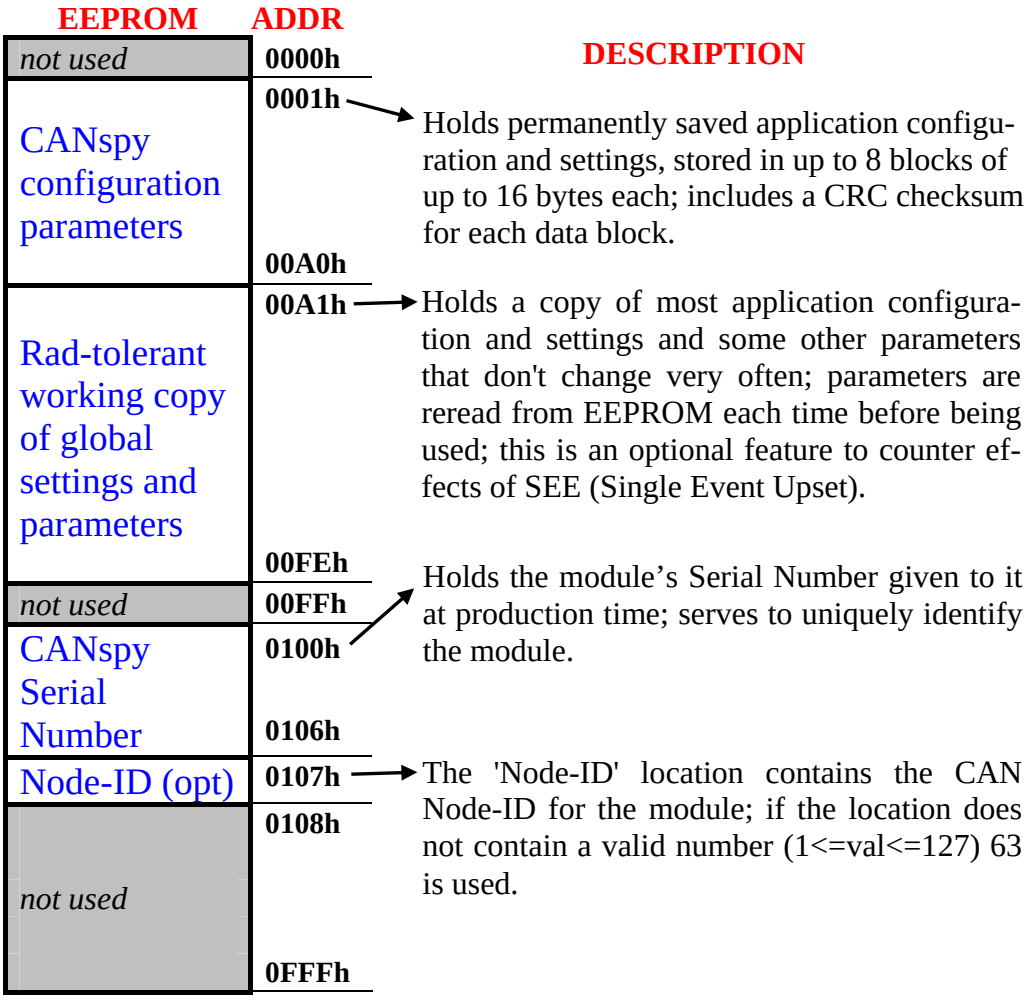

EEPROM
ADDR
DESCRIPTION
not used
0000h
0001h
CANspy configuration parameters
Holds permanently saved application configuration and settings, stored in up to 8 blocks of up to 16 bytes each; includes a CRC checksum for each data block.
00A0h
00A1h
Rad-tolerant working copy of global settings and parameters
Holds a copy of most application configuration and settings and some other parameters that don't change very often; parameters are reread from EEPROM each time before being used; this is an optional feature to counter effects of SEE (Single Event Upset).
00FEh
not used
00FFh
CANspy Serial Number
0100h
Holds the module's Serial Number given to it at production time; serves to uniquely identify the module.
0106h
Node-ID (opt)
0107h
The 'Node-ID' location contains the CAN Node-ID for the module; if the location does not contain a valid number (1<=val<=127) 63 is used.
not used
0108h
0FFFh

Table 4. AT90CAN64 microcontroller EEPROM memory map of the *CANspy* application firmware.

4.4 Upgrading the Firmware

The application program in the *CANspy* microcontroller can be replaced or upgraded by uploading new program code via its control CAN connection.

A Windows application program called **ELMBloader** is available for performing this firmware upgrade (it was developed for the *ELMB* module which contains an ATmega128 microcontroller, but has since been upgraded to operate on AT90CAN microcontrollers too, provided they have been programmer with the proper bootloader firmware; see below). The upgrade process leaves the EEPROM intact, in other words: all existing configuration settings are preserved during an upgrade.

The ***Bootloader*** [3] is an application program stored in a separate section of the microcontroller flash memory. It handles the firmware upgrade process, receiving series of CAN(open) messages containing the programming instructions and code.

After power-up of the *CANspy* module, it is always the *Bootloader*, that takes control of the module. After about 4 seconds the *Bootloader* automatically jumps to the start of the *CANspy* application program, or immediately, when it receives a CANopen ***NMT*** *Reset-Node* message. However, the *Bootloader* remains in control if it receives a valid programming command within those 4 seconds. The firmware upgrade process may then begin.

The *CANspy* application program can transfer control of the module explicitly to the *Bootloader*, when one writes any value to the 8-bit object 5E00h in the Object Dictionary of the *CANspy* application. In this case the *Bootloader* does *not* automatically jump to the *CANspy* application program after 4 seconds. The firmware upgrade process may now begin.

After the upgrade process, the reception of a CANopen ***NMT*** *Reset-Node* message causes the *Bootloader* to jump to the start of the new application program.

If the *CANspy* module sends an *Emergency* message as shown below, it signifies that the *Bootloader* is in control of the module. Note that the same Emergency message is also sent as the first message after power-up, when the *Bootloader* is in control for the first 4 seconds after power-up, before jumping to the application program.

The *Bootloader* can be forced to jump to the application immediately, by sending it a CANopen ***NMT*** Reset-Node message.

COB-ID	Byte 0-1	Byte 2	Byte 3-7
080h + *NodeID*	Emergency Error Code (00h 50h)	Error Register (Object 1001h) (80h)	Manufacturer specific error field (5 bytes: FEh,80h,64h,*ZZh*,00h, with *ZZh* = MCUSR)

(*MCUSR* = MCU Status Register contents; for details see section 4.6).

4.5 CANspy Object Dictionary

The values of objects marked with ∗ in the *Index* column can be stored permanently in EEPROM. They are retrieved from EEPROM at reset and power-up.

Communication Profile Area (*CANspy*)						
Index (hex)	**Sub Index**	**Description**	**Data/ Object**	**Attr**	**Default**	**Comment**
1000	-	Device type	U32	RO	00000000h	Meaning: no specific device profile
1001	-	Error register	U8	RO	0	
1002	-	Manufacturer status reg	U32	RO	0	[1] (see footnote)
1008	-	Manufacturer device name	VisStr	RO	"CSPY"	= CANspy module
1009	-	Manufacturer hw version	VisStr	RO	"CS10"	= CANspy v1
100A	0	Manufacturer software version	VisStr	RO	"CS10"	***CANspy*** application v1.0.0
	1	minor version number	VisStr	RO	"0000"	
100C	-	Guard time [ms]	U16	RO	1000	= 1 second
100D *	-	Life time factor	U8	RW	0	Life Guarding timeout in seconds; 0 → no life guarding timeout
1010		Store parameters	Array			Save stuff in onboard EEPROM
	0	Highest index supported	U8	RO	3	
	1	Save all parameters	U32	RW	1	Read: 1; Write "save": store all
	2	Save communication parameters	U32	RW	1	Read: 1; Write "save": store PDO par's, Life time factor, …
	3	Save application par's	U32	RW	1	Read: 1; Write "save": store ADCs config, …
1011		Restore default parameters	Array			Invalidate stuff in onboard EEPROM; use defaults
	0	Highest index supported	U8	RO	3	
	1	Restore all parameters	U32	RW	1	Read: 1; Write "load": invalidate all parameters stored
	2	Restore communication parameters	U32	RW	1	Read: 1; Write "load": invalidate stored PDO par's, etc.
	3	Restore application par's	U32	RW	1	Read: 1; Write "load": invalidate stored ADCs config, etc.
1017 *	-	Producer Heartbeat Time [1 s]	U16	RW	0	In units of seconds (but <=255 !), (NB: actually should be in ms according to CANopen!); 0 → Heartbeat is disabled
1018		Identity	Record			Mandatory CANopen object
	0	Number of entries	1..4	RO	1	
	1	Vendor ID	U32	RO	12345678h	to be ordered from CiA

[1] Manufacturer Status Register: byte0 = ….

Manufacturer-specific Profile Area (*CANspy*) ***(continued…)***						
Index (hex)	**Sub Index**	**Description**	**Data/ Object**	**Attr**	**Default**	**Comment**
2000	-	CAN Port Switch	U8	RW		0: disconnect 1 to 32: connect CAN port
2010	-	Open Detection Mask	U32	RO		"LED Open Detection" bits of the TLC5923 devices
2020	-	Dot Correction	U8	RW		LED Dot Correction setting for the TLC5923 devices; all outputs get the same value (default: 63, maximum 127)
2030	-	Error Flags	U8	RO		Bit 0: TLC5923 XERR active Bit 1: TLC5923 TEF active
2040	-	CANspy LCD description string (char position 1 to 4)	U32	RW		e.g. for "ABCD" write value 44434241h
2041	-	CANspy LCD description string (char position 5 to 8)	U32	RW		
2050		CAN port LCD description string (char position 1 to 4)	U32	RW		String for display on the LCD
	0	Number of entries	U8	RO	32	
	1	CAN port 1	U32	RW		
	…	…	…	…		
	32	CAN port 32	U32	RW		
2051		CAN port LCD description string (char position 5 to 8)	U32			String for display on the LCD
	0	Number of entries	U8	RO	32	
	1	CAN port 1	U32	RW		
	…	…	…	…		
	32	CAN port 32	U32	RW		
2100	-	LCD data byte	U8	RW		*(for test purposes)*
2110	-	LCD (DDRAM) addr byte	U8	RW		*(for test purposes)*
2120	-	LCD busy bit	U8	RO		*(for test purposes)*

Manufacturer-specific Profile Area (*CANspy*) *(continued…)*						
Index (hex)	**Sub Index**	**Description**	**Data/ Object**	**Attr**	**Default**	**Comment**
3000		Program Code CRC	Record			
	0	Number of entries	U8	RO	3	
	1	Check 16-bit CRC of program code in FLASH memory	U16	RO	0	SDO reply unequal to zero means there is a checksum error; absence of CRC results in SDO *Abort* with *Error Code* 1; error while accessing FLASH results in SDO *Abort* with *Error Code* 6.
	2		U16	RO	0	*not used*
	3	Get CRC	U16	RO		Return CRC from flash
3100	-	Serial Number	U32	RW		Number or 4-byte string uniquely identifying a *CANspy* module, given during production.
3101	-	Enable Serial Number write operation	U8	WO		Writing 5Ah enables one write operation on the Serial Number (Object 3100) [1].
3200		CAN-controller settings and status	Record			
	0	Number of entries	U8	RO	4	
	1	Format error interrupt counters	U32	RO		Byte 0: SERG Byte 1: CERG Byte 2: FERG Byte 3: AERG
*	2	Enable auto-start	U8	RW	0	If =1 go to *Operational* at startup
*	3	Bus-off max retry counter	U8	RW	2	Counter is decremented every 1s, but if the node reaches this maximum value it abandons regaining CAN-bus access
	4	Received message counter	U8	RO		Counts received CAN messages modulo 256 (for debug purposes)
3300	-	CAN Node Identifier	U8	WO		The new CAN Node Identifier is used after the next reset. (*Bootloader* firmware version 1.3 and later supports this feature, otherwise don't use it !)
3301	-	Enable CAN Node Identifier write operation	U32	WO		Writing a number that matches the Serial Number (Object 3100) enables one write operation on the CAN Node Identifier (Object 3300) [2].

[1] The Serial Number is set during production, and is not to be changed by the user !

[2] The CAN Node Identifier has been set during production but can be changed if the need arises (e.g. if the *CANspy* module is connected to a CAN bus where the Node Identifier already exists).

Manufacturer-specific Profile Area (*CANspy*) *(continued…)*						
Index (hex)	**Sub Index**	**Description**	**Data/ Object**	**Attr**	**Default**	**Comment**
5C00	-	Compile-time Options	U32	RO		Bitmask denoting which compile options were used when the application code was generated (see table below for details)
5E00	-	Jump to Bootloader app	U8	WO		

Object 5C00: Compile Options		
Bit	***Option***	***Comment***
0	VARS_IN_EEPROM	Store/retrieve working copies of configuration parameters in/from EEPROM
1	–	–
2	–	–
3	–	–
4	–	–
5	AT90CAN32	Code compiled for AT90CAN32 microcontroller
6	AT90CAN64	Code compiled for AT90CAN64 microcontroller
7	AT90CAN128	Code compiled for AT90CAN128 microcontroller

4.6 Emergency Objects

CANopen *Emergency* messages are triggered by the occurrence of an internal (fatal) error situation. An *Emergency* CAN-message has the following general syntax:

CANspy → Host

COB-ID	Byte 0-1	Byte 2	Byte 3-7
080h + *NodeID*	Emergency Error Code	Error Register (Object 1001h)	Manufacturer specific error field

A toggle bit is present in byte 7 of the Emergency message. Byte 7 alternates between the values 00h and 80h from one Emergency message to the next.

The following Emergency messages can be generated by the **CANspy** application:

Error Description	Emergency Error Code (byte 1-0; hex)	Manufacturer-specific Error Field (byte 3-7)
CAN communication	8100	Byte 3: 00h Byte 4: total format error count Byte 5: error counter Byte 6: bus-off counter (see OD index 3200, sub 3)
CAN buffer overrun	8110h	CAN message buffer in RAM full: at least 1 message was lost
Life Guarding time-out	8130	CAN-controller has been reinitialized
Switch error	5000	Byte 3: 01h Byte 4: 0 if only 'LED Open Detection' flag set, 1 if 'Temperature Error' flag set
CRC error	5000	Byte 3: 30h Byte 4: 1 (program FLASH)
EEPROM: write error	5000	Byte 3: 41h Byte 4: Parameter block index [1] Byte 5: 0 : writing block info > 0: size of parameter block to write
EEPROM: read error	5000	Byte 3: 42h Byte 4: Parameter block index [1] Byte 5: Error id (1=CRC, 2=length, 4=infoblock)

…table continues on the next page…

[1] **0**: ---, **1**: Guarding parameters, **2**: ---, **3**: ---, **4**: ---, **5**: ---, **6**: CAN configuration parameters, **7**: ---, **FFh**: CANspy Serial Number.

Error Description	Emergency Error Code (byte 1-0; hex)	Manufacturer-specific Error Field (byte 3-7)
Irregular reset (Watchdog, Brown-out or JTAG)	5000	Byte 3: F0h Byte 4: microcontroller MCUSR register contents [1]
Bootloader: not present	5000	Byte 3: F1h
Bootloader is now in control [2]	5000	Byte 3: FEh Byte 4: 80h Byte 5: 64h Byte 6: microcontroller MCUSR register contents [1]
Bootloader cannot jump to application: invalid [2]	6000	Byte 3: FEh Byte 4: AAh Byte 5: AAh

Byte 2 of the *Emergency* message contains the value of the socalled *Error Register* (Object Dictionary index 1001h, a mandatory CANopen object). One or more bits of the 8-bit Error Register can be set to 1, depending on the node's history of errors since the last reset. The table below gives a description of the different bits.

Error Register (Object 1001h) bits	
Bit	**Error type**
0	generic
1	current
2	voltage
3	temperature
4	communication
5	device profile specific
6	*reserved (=0)*
7	manufacturer specific

[1] AT90CAN64 *MCUSR* register bits: **01h**: Power-On Reset, **02h**: External Reset, **04h**: Brown-Out Reset, **08h**: Watchdog Reset, **10h**: JTAG Reset.

[2] This Emergency message is generated by the Bootloader program !

References

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